A new methodological approach for analysing river basins landscape changes

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Research indicates that the Jordan River Basin area is an area where serious environmental and cultural changes occur. This paper illustrates a new methodological approach to developing a structural framework to study river basins' cultural and landscape changes. The aim of the proposed framework is to elaborate and overlap the natural and cultural driving forces that influence the landscape and to understand the relationship between them. The study consists of four stages: 1. setting specific objectives coinciding with the study area conditions and specifications; 2. defining a specific technique to determine the selected time frame; 3. defining the factors of each driving force and evaluating their correspondence with the study objectives, and finally; 4. building matrixes of intersections combining the natural force, the cultural force, and the overlapping between both, and adopting specific methodological techniques and tools to measure the outcome of each intersection. The paper presents a case study of the application of the proposed framework in the Jordan River Basin. The research results demonstrate the usefulness of the developed framework in understanding the overlapping between the landscape driving forces (natural and cultural) as well as achieving the goals of the related research. This new approach can facilitate a better understanding of landscape change and help researchers and planners identify and address the key issues related to sustainable landscape management by developing more effective policies and management strategies.

Keywords: structural framework, comparative matrix, landscape changes, river basins, management policies

1   Introduction

The Jordan River Basin area has attracted significant attention from researchers and policymakers due to the occurrence of substantial environmental and cultural changes. To ensure the sustainable management of landscapes, it is crucial to comprehend and track these changes and their impacts on the environment. The main goal of this paper is to introduce and develop a structural framework for analysing and overlapping the cultural and landscape-driving forces of change within river basins, with a specific focus on the Jordan River Basin. This research identifies a significant gap in the current landscape changes and cultural studies as prior research has concentrated on a single and separate driving force of landscape change, underscoring the necessity of adopting a comprehensive viewpoint that integrates the analysis of both cultural and natural forces of change.

The driving force of change describes any force or element that has the capacity to cause change. The interplay between:

1. natural driving force that refers to inherent and environmentally rooted force that exerts influence on the dynamics of a given landscape or ecosystem;
2. cultural driving force, which conversely, pertains to external influences stemming from human activities and sociocultural constructs that impact the landscape;
3. their combined influence on landscapes, has long been a topic of interest in diverse research disciplines.

While studies have individually explored either the natural or cultural force of landscape changes, a comprehensive framework that effectively integrates these forces and investigates their overlapping processes is still lacking. The proposed framework presented in

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this study aims to bridge this research gap by providing a systematic approach to analyse and understand the intricate relationship between natural and cultural forces in shaping river basin landscapes, aiding in the identification and resolution of pivotal challenges associated with sustainable landscape management through the formulation of more efficacious policies and management strategies.

To comprehend the complex analysis of river basin landscapes, it is crucial to consider the interdependencies and interactions between natural and cultural forces. Natural force encompasses a range of factors such as climate, geology, hydrology, and biodiversity, which play significant roles in shaping the physical characteristics and ecological processes of a landscape (Grabowski et al., 2022). On the other hand, cultural force encompasses human activities, practices, beliefs, and values that shape cultural landscapes (Antrop, 2005). These include factors such as land use practices, urbanization, agriculture, infrastructure development, and socio-economic factors (Turner et al., 2008).

This work holds considerable significance as the Jordan River Basin area serves as a crucial case study due to the profound natural and cultural changes occurring in the region. Examining this context can enhance our understanding of the broader implications for global river basin landscapes.

A review of the current state of research in the field reveals that while studies have explored either the natural or cultural forces of river basin landscapes, few have effectively integrated both. This lack of integration restricts the comprehensive understanding of landscape changes and hampers the development of sustainable management strategies. By addressing this gap, the proposed framework offers a fresh approach that bridges the division between natural and cultural sciences, providing a holistic perspective on landscape dynamics.

The understanding of landscape changes and the interplay between natural and cultural forces have been significantly advanced through seminal publications in the field. Notably, Samuels et al. (2010) conducted a comprehensive review focused on the impacts of climate change in the Jordan river basin. Their study emphasized the urgency and complexity of the challenges faced by the region, shedding light on the need for effective management strategies. The work of Samuels et al. (2010) highlights the critical role of climate change in driving landscape changes, underscoring the importance of considering climatic factors in the proposed methodological framework.

In a study by Wang et al. (2022), methods and approaches for studying cultural landscape changes in river basins were thoroughly reviewed. The authors emphasized the necessity of integrated frameworks to capture the multidimensional factors of cultural changes and their interconnectedness with natural changes. Wang et al. (2022)'s research highlighted the limitations of existing approaches that predominantly focused on isolated factors of landscape changes and emphasized the need for a holistic perspective that incorporates cultural and natural forces of change. Their findings align with the objectives of the present study, as the proposed methodological approach aims to bridge the gap between cultural and natural forces of change to comprehensively understand landscape changes.

Shafaghat et al. (2017) proposed a conceptual framework that addressed the integration of natural and cultural heritage management in riverscapes. Their work emphasized the significance of considering both dimensions when developing management strategies to ensure the preservation of river landscapes. By emphasizing the importance of integrating natural and cultural forces, Shafaghat et al. (2017) underscored the need for a comprehensive understanding of landscape changes. This aligns with the objectives of the present study, as the proposed methodological framework aims to provide a systematic approach to analyse the interplay between natural and cultural forces in shaping river basin landscapes.

These seminal publications collectively emphasize the significance of integrating natural and cultural forces to comprehensively understand landscape changes. The studies conducted by Samuels et al. (2010), Wang et al. (2022), and Shafaghat et al. (2017) provide valuable insights into the complex changes that shape river basin landscapes. By highlighting the urgency of addressing environmental and cultural impacts and changes, the need for integrated frameworks, and the importance of considering both natural and cultural forces, these publications lay the foundation for the proposed methodological approach presented in this study.

The proposed four-stage approach outlined in this study provides a structured methodology to achieve the study objectives. This novel approach offers the potential to enhance comprehension of landscape changes, aiding researchers and planners in the identification and resolution of critical challenges associated with sustainable landscape management through the formulation of more effective policies and management strategies. For instance, consider a practical example in the context of a river basin: by integrating natural and cultural driving forces, this approach can assist

in elucidating how climate change impacts land use practices, ultimately guiding the development of policies that promote sustainable agriculture and mitigate environmental degradation, thus contributing to the overall resilience of the landscape as well as analysing the cultural shifting and displacement, and the sense of belonging. This framework helps in identifying the influence of political agreements, facilitates comparative analysis, informs policymaking and land-use planning, preserves cultural heritage, and supports sustainable tourism.

2 Material and methods

2.1 Materials

This study employed the case study of the Jordan River Basin as a means to apply an analytical framework (Figure 1). Originating from the Anti-Lebanon and Mount Hermon Mountain ranges, the Jordan River covers 223 km from North to South and discharges into the Dead Sea. The river has five riparians: Palestine, Jordan, Lebanon, Israel, and Syria. The Jordan River Basin is the area of land that is drained by the Jordan River and its tributaries. It covers an area of about 18,000 square kilometres. The Jordan River Basin is in the Middle East, and it is bordered by the Mediterranean Sea to the west, the Golan Heights and the Anti-Lebanon Mountains to the north, the West Bank and the Dead Sea to the south, and the Arabian Desert to the east. The Jordan River Basin area shares are 10% for Israel, 40% for Jordan, 4% for Lebanon, 9% for Palestine, and 37% for Syria. It flows through several valleys that are formed by the river and its tributaries. These valleys are known for their natural beauty, historical and cultural significance, and economic and political importance.

The Jordan River Basin is globally recognized for its significant natural importance, encompassing ecological, hydrological, and biodiversity attributes. It is located in a geographically diverse region as it encompasses a wide range of topographical features and ecological zones. The basin is situated at the intersection of several major tectonic plates, which has led to the formation of a variety of landforms. It holds immense hydrological significance, serving as a crucial water source for multiple countries in the region, and playing a pivotal role in the regional water cycle, sustaining human livelihoods and supporting economic activities (Gunkel & Lange, 2012).

The Jordan River Basin has also long been a site of cultural importance, revered in various religious traditions and serving as a symbolic landmark. The basin encompasses numerous sacred sites, including the baptismal site of Jesus Christ, which holds immense significance for Christian pilgrims (de Châtel, 2014). The basin's cultural heritage extends beyond religion with archaeological sites that offer insights into ancient civilizations and human history. For instance, the Jericho archaeological site within the basin is one of the oldest inhabited cities in the world, providing valuable evidence of human settlements and cultural practices dating back thousands of years. The cultural significance of the Jordan River Basin is further accentuated by its association with narratives and legends that have permeated cultural narratives for centuries, contributing to the region's rich folklore and traditional heritage (Peppard, 2013).
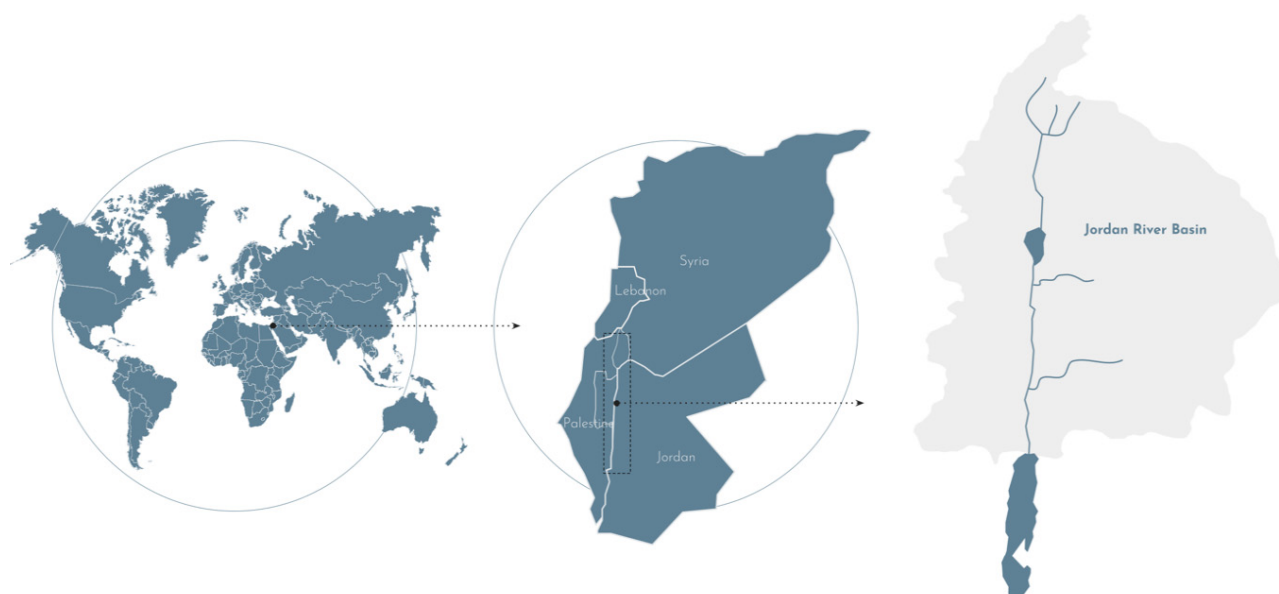

Figure 1 Jordan River Basin location

The Jordan River Basin has been a focal point of political contention and negotiation among the riparian countries sharing its resources. The basin's limited water availability and the increasing demand for water resources have led to disputes and conflicts over water allocations and management strategies (Newman, 2003). The political significance of the Jordan River Basin is particularly evident in the context of the Israeli occupation of the Palestinian lands, where water resources, including the Jordan River, play a critical role in determining political boundaries, sovereignty, and regional stability (Jägerskog, 2007). The basin's geopolitical complexities are further exacerbated by the involvement of neighbouring countries, such as Jordan and Syria, which have their own water-related concerns and interests (Jägerskog, 2007). Consequently, the management and utilization of the Jordan River Basin's water resources have become intertwined with regional politics and have implications for peacebuilding efforts and regional cooperation.

2.2 Methods

In this research, a methodological approach encompassing four distinct stages was employed with the objective of developing a comprehensive structural framework for investigating the intricate relationship between cultural and natural driving forces within river basins. The primary aim of this framework was to enhance the understanding of cultural and landscape changes occurring within the selected case study. It is pertinent to note that each driving force has several principles of comparison to determine its diversity and help in selecting the suitable part of the river to be studied. As well as comprises a multitude of contributing factors that exert influence on landscape change. To achieve this objective, the methodology required careful consideration of three critical inputs that framed the four methodological stages: the context, the temporal scope, and the selection of driving forces, followed by the application of four main stages:

2.2.1 Stage 1: Setting specific objectives coinciding with the study area conditions and specifications (site selection criteria)

Drawing on the availability and accessibility of data and resources, three parts of the Jordan River (The selected case study) were designated to put through a selection methodology (The river tributaries refer to a smaller river or stream that flows into the main Jordan River within the Jordan River Basin. It includes the river or stream itself and the surrounding landscape that contributes to the flow of water, the river valleys- the low-lying region through which the Jordan River flows, and the river basin which is a larger geographical area that includes the

Jordan River and all the land that drains into the river). The first step is to define the principles and parameters of the comparison. Comparison principles serve as a foundation to consider the interdependencies and interactions between different driving forces:

1. Natural Principles of Comparison (they help in selecting the most naturally diverse part of the river):
   - Accessibility to the data resources: this is defined by the possibility of the researcher reaching and using the available natural data resources.
   - Climate diversity: evaluating which part of the river has a more diverse climatic condition than the other.
   - Geological diversity: evaluating which part of the river has a more diverse geological diversity than the other (Manosso et al., 2021).
   - Morphological diversity: evaluating which part of the river has more morphological diversity than the other (mountains, hills, rivers, coasts, and human settlements and works) (Roy & Foote, 1997).
   - Vegetation diversity: evaluating which part of the river has a more variety or mixture of plants and animal species, and vegetation age classes. As well as the factors responsible for the diversity (Temperature, soil, relief, and sunlight) (Liccari et al., 2022).
   - Protected areas: evaluating which part of the river covers a bigger amount of natural protected areas (For example, UNESCO Natural Protected Reserves; Dana Biosphere Reserve) (Pulido-Chadid et al., 2023).
   - Water-management policies: define the water management policies that are decided by governments and which part of the river has the highest level of precautions when it comes to water management (Özerol et al., 2018).

2. Cultural principles of comparison (they help in selecting the most diverse cultural part of the river):
   - Accessibility to the data resources: this is defined by the possibility of the researcher reaching and using the available cultural data resources (Zander & Kralisch, 2016).
   - Cultural diversity (human-settlement patterns): measuring the patterns of social norms and societies that settled in the three selected parts of the river throughout history (Fang et al., 2018).
   - Land-use diversity: assessing which part of the river has a more mixed land use or if the function of the lands has changed throughout history (Ren et al., 2022).

- Shared ownership: how many countries own each selected part, and which one is owned by more parties than the other?
- The cultural heritage sites: evaluating which part of the river covers a bigger amount of cultural heritage sites; including artifacts, monuments, a group of ancient buildings and sites, sites with social significance, and ethnological and anthropological sites (Wang et al., 2023).
- The recreational-tourism sites: evaluating which part of the river covers a bigger number of recreational-touristic sites, which are the sites that are mostly visited by tourists such as castles, ruins, or any other heritage attractions.
- The intensity of use: evaluating which part of the river is more used by people or has a bigger number of residences and tourists (Arnberger et al., 2023).
- Accessibility to visit: evaluating which part of the river is easier to approach or access.

3. Political principles of comparison:
   - Accessibility to the data resources: this is defined by the possibility of the researcher reaching and using the available political data resources.
   - Jurisdictional boundaries: which part of the river has a more political, administrative, and geographical border?
   - Agreements and cooperation: which part of the three selected areas are labelled with more political agreements and cooperation?
   - Shared ownership: how many countries own each selected part, and which one is owned by more parties than the other?

The second step is building a comparative matrix to study the influence of each principle on each part of the river. The evaluation methodology to choose the study area is determined by defining the impact level of the principle of comparison on the three selected study areas using three levels of measurement (a high level represented by a green circle, a medium level represented by a yellow circle, and a low level represented by a red circle). The evaluation process is theory-based.

2.2.2 Stage 2: Defining a specific technique to determine the selected time frame (a fixed parameter)

This stage focuses on selecting a fixed parameter to achieve the goal of creating a complex comparison between the landscape driving forces overlapped on the landscape change along the Jordan River basin. The more specific the factor of change (parameter) was, the more precise the result of the analysis becomes. According

to the context, the timescale parameter forms a shared turning point of events for each driving force of change. Thus, the timescale was chosen to be the fixed parameter among the driving forces. The timescale consists of an important period regarding the nature and culture of the study area. The selected timeframe represents the political Agreements and Cooperation by analysing and measuring the impact of the selected driving forces on the landscape change of the Jordan River basin before and after each political agreement/cooperation.

2.2.3 Stage 3: Defining the factors of each driving force and evaluating their correspondence with the study objectives

In this stage, each factor was scrutinised and assessed in terms of its significance and potential influence on the landscape and cultural changes within the study area. This evaluation ensured that the selected factors were aligned with the context conditions, thereby enabling a comprehensive analysis of their interrelationships and impacts. The factors of the driving forces can be categorized into two main groups: natural factors encompassing climate diversity, precipitation, geology, morphology, soil type, topography (including land use and land cover), hydrology, groundwater, as well as human intervention and activities, along with regulations and protected areas. On the other hand, cultural factors encompass cultural significance, historical context, cultural heritage and tourism, identity and attachment, and socio-economic factors.

2.2.4 Stage 4: Building matrixes of intersections combining the natural force, the cultural force, and the overlapping between both, and adopting specific methodological techniques and tools to measure the outcome of each intersection

In the final stage of the methodology, a comparison between the driving forces was conducted. This process involved several steps to facilitate a comprehensive analysis: The initial step involved a meticulous selection and elimination of factors for each driving force, considering their significance and impact on the study area, and their relation to the study objective. Subsequently, the selected factors were systematically overlapped through the construction of a comprehensive comparison matrix. This matrix was structured by aligning the same factors along the X and Y axes, facilitating a rigorous evaluation of their intersectional dynamics. To accurately assess the outcomes of these intersections, the most suitable technique was employed, ensuring a robust measurement and analysis approach to define the main
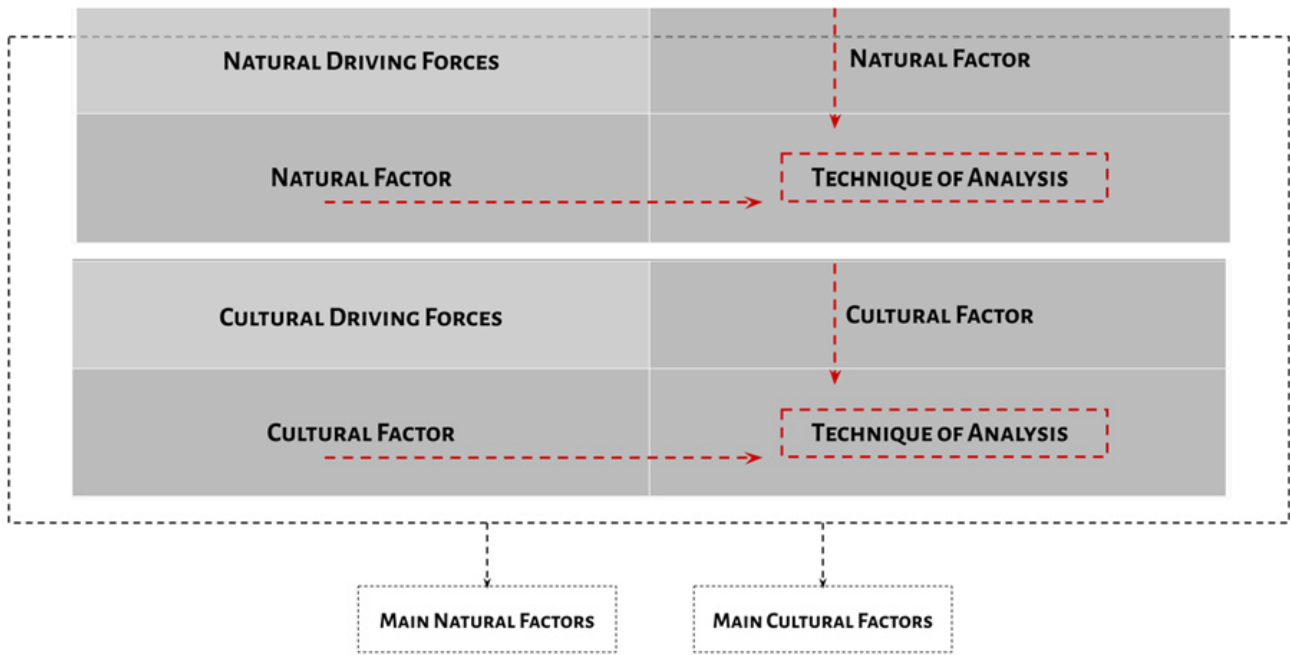
Figure 2   Natural and cultural driving force matrix

natural factors and the main cultural factors affecting the study area, and yielding results that are summarized in the accompanying figure (Figure 2).

In the final step of this analytical stage, the paramount emphasis lies in covering the main natural driving factors and the main cultural driving factors identified in the preceding step. This is achieved by systematically aligning the main natural factors along the *X*-axis and the main cultural factors along the *Y*-axis of the final analytical matrix. To ascertain the outcomes of these intersections, the adoption of the most applicable measurement technique becomes imperative. By diligently executing this step, the prevailing direction of landscape transformation within the river basin area can be unveiled. The intricate integration of the main natural and cultural driving factors in the analytical matrix engenders a comprehensive understanding of the multifaceted dynamics shaping the landscape, thus contributing to the elucidation of the intricate interplay between natural and cultural forces in the studied river basin context (Figure 3).
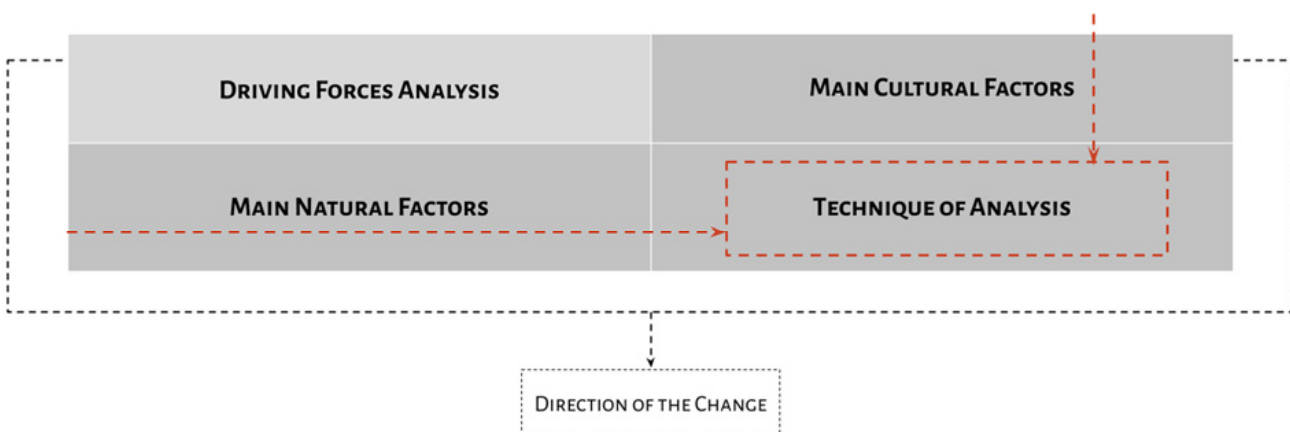

Figure 3   Driving forces matrix

3   Results and discussion

The findings of this research are categorized according to the four distinct methodological stages employed in the study. Through a systematic and rigorous approach, these stages were designed to ensure a comprehensive analysis and interpretation of the data. By dividing the results in alignment with the methodological framework, the study aims to provide a clear and structured presentation of the key outcomes. This meticulous organization of findings facilitates a deeper understanding of the research process and enables readers to discern the unique contributions and implications of each stage.

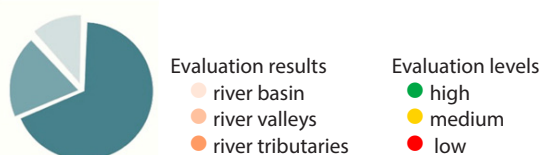### 3.1 Stage 1 Result: Site selection (river part selection)

Subsequent to the alignment of the river parts along the *X*-axis and the parameters of comparison along the *Y*-axis, the evaluation procedure commenced by assigning distinctively coloured circles to signify the influence of each analytical parameter on the respective river part. Consequently, an assessment of the principles' impact on the Jordan River basin revealed the highest percentage among the three studied regions. As a result, the Jordan River basin was determined as the designated study area. This selection is confirmed by the substantial magnitude of the principles' impact observed within the basin, indicating its significance in the context of the research inquiry. Table 1. illustrates (vertically, the principles of comparison based on the selected driving forces and horizontally, the three nominated parts of the selected case study) (Table 1).

The findings of this study indicate that the principles of comparison exhibit the most pronounced impact

Table 1   Site selection results and evaluation

Parameters		Principles of comparison	River tributaries	River valleys	River basin
		Natural principles	**Driving force 01**		
	1	accessibility to the data resources	🔴	🟡	🟢
	2	climate diversity	🔴	🟡	🟢
	3	geological diversity	🔴	🟡	🟢
	4	morphological diversity	🟡	🟡	🟢
	5	vegetation diversity	🟢	🟢	🟢
	6	protected areas	🔴	🟢	🟢
	7	water-management policies	🟢	🟢	🟢
		Cultural principles	**Driving force 02**		
	1	accessibility to the data resources	🔴	🟢	🟢
	2	cultural diversity (human-settlement patterns)	🟡	🟡	🟢
	3	land-use diversity	🟡	🟡	🟢
	4	shared ownership	🟡	🔴	🟢
	5	the cultural heritage sites	🔴	🟡	🟢
	6	the recreational-tourism sites	🟢	🟢	🟢
	7	the intensty of use	🔴	🟡	🟢
	8	accessibility to visit	🔴	🔴	🟡
		Political principles	**Driving force 03**		
	1	accessibility to the data resources	🔴	🔴	🟢
	2	jurisdictional boundaries	🟡	🔴	🟢
	3	agreements and cooperation	🔴	🟡	🟢
	4	shared ownership	🟡	🔴	🟢

Evaluation results
- river basin
- river valleys
- river tributaries

Evaluation levels
- 🟢 high
- 🟡 medium
- 🔴 low

on river basins among the various river parts examined. Additionally, the results reveal that the river basin encompasses both valleys and tributaries within its spatial boundaries. Consequently, the applicability of this study extends beyond the specific river parts investigated, suggesting its potential utility for assessing other areas within the broader confines of the river basin.

3.2 Stage 2 Result: Time frame selection

The selection of the timescale as a fixed parameter among the three driving forces is motivated by its significance in understanding the dynamics of the Jordan River basin. The timescale chosen corresponds to a crucial period that holds considerable relevance to the nature of the basin. Specifically, with regard to political agreements and cooperation, the analysis focuses on assessing and quantifying the influence of the driving forces on landscape change within the Jordan River basin before and after each instance of political agreement or cooperation (Figure 4) (A) represents Political Agreements (C) represents Political Cooperation, and (A/C) represents both.

The timescale serves as a valuable tool in this study as it allows for a focused investigation into the impact of political agreements and cooperation on the landscape of the Jordan River basin. As well as, creates a multi-layered vision of analysis for the landscape driving forces of change. This approach enables a comprehensive examination of the relationship between politics

and landscape dynamics in the basin, enhancing comparability across different periods of political intervention. However, it is important to acknowledge potential limitations in this methodological approach. The selection of a specific timescale may inherently introduce a degree of subjectivity, as alternative periods could yield different results. Additionally, the availability and reliability of data for specific time periods may vary, potentially influencing the comprehensiveness and accuracy of the analysis. Future research could explore alternative approaches to incorporating temporal dynamics into the analysis. For instance, adopting a more flexible or adaptive timescale that adjusts based on the emergence of significant events.

3.3 Stage 3 Result: Defining the main factors (intersections and elimination process)

During the elimination process, specific factors from each driving force were carefully assessed based on several criteria. Some factors were excluded if they did not align with the research objectives, lacked sufficient data resource availability within the context of the study, or were not relevant to the selected location and climate. This thorough selection process ensured that only the most pertinent factors were retained for further analysis, thereby enhancing the validity and applicability of the research findings. Based on the selected contextual area. The eliminated factors include (Geology/soil, Hydrology/groundwater, and Laws/regulations from the natural driving force) and (Socioeconomic and national
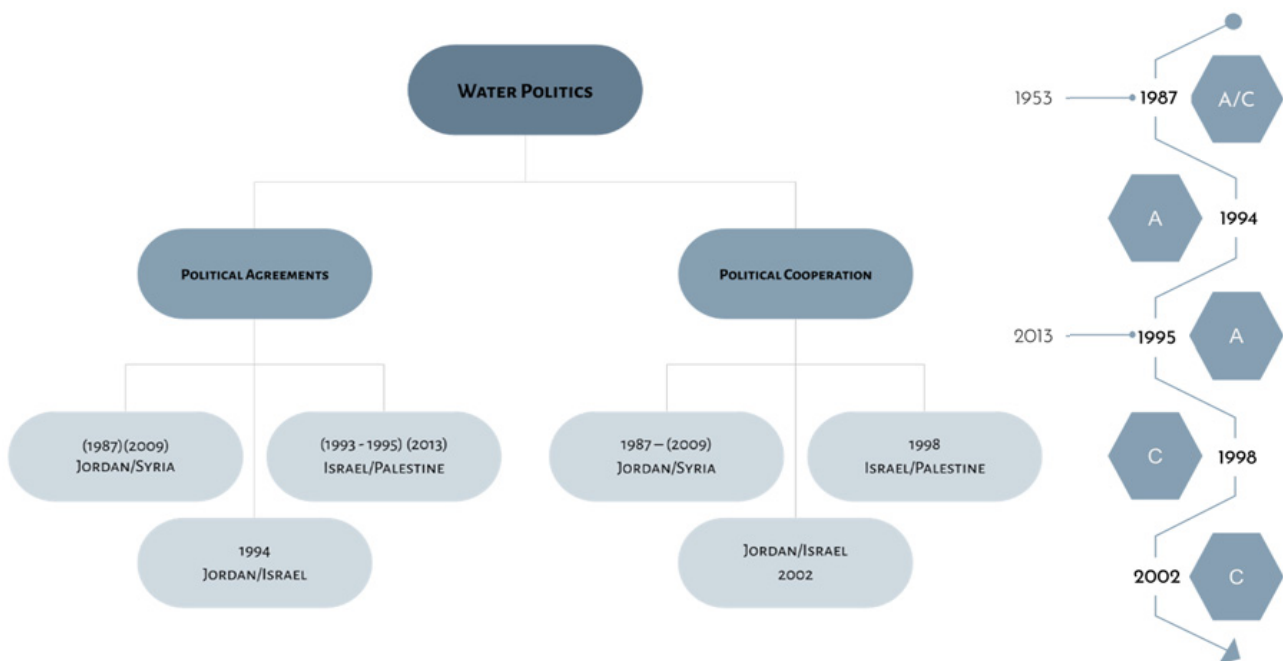

Figure 4   Timelinex

culture from the cultural driving force). It is important to acknowledge that this elimination occurred due to the lack of sufficient resources for each factor separately from another to be considered in the selected context and applied in future studies; nevertheless, it is crucial to recognize that the outcomes may differ according to the unique characteristics of the specific context being investigated.

The intersection process undertaken in this study encompasses a comprehensive analysis of each driving force independently as well as the intersection between the two forces. Specifically, the factors associated with the natural driving force were organized along the *X*-axis and intersected with themselves, leading to their arrangement along the *Y*-axis as well. The same methodology was applied to the factors pertaining to the cultural driving force. This rigorous analytical approach facilitated the identification of a research technique example for measuring the intricate interactions among the natural factors, and subsequently, for the cultural factors. Furthermore, a matrix of analysis was constructed, aligning the main natural factors on the *X*-axis with the main cultural factors on the *Y*-axis. This matrix facilitated the determination of appropriate techniques to quantitatively assess the outcomes of each intersection, thus providing insights into the direction of landscape change within the river systems.

3.4 Stage 4 Result: Effective policies and management strategies

The intersection matrix approach offers context-specific policies and management strategies contingent upon the outcomes of the analysis. Potential applications encompass integrated landscape planning, wherein the matrix identifies areas of convergence between natural and cultural factors, prompting coordinated efforts in land use, conservation, and infrastructure development. Ecosystem-based approaches can be facilitated by recognizing areas of alignment between the driving forces, emphasizing the enhancement of ecosystem functions to support ecological and human well-being. Stakeholder engagement and collaboration can be fostered through the identification of key actors and their roles, leading to the development of collaborative governance frameworks for sustainable landscape management. The dynamic interaction between natural and cultural factors, as revealed by the research, necessitates adaptive management strategies involving iterative learning, monitoring, and adjustment to address evolving conditions and uncertainties. Conservation and restoration prioritization can be guided by the matrix analysis, allowing for the identification of priority areas based on the significance and overlap of factors, thus

optimizing biodiversity conservation, cultural heritage preservation, and sustainable land use. Furthermore, the intersection matrix findings can inform the development of education and awareness programs, promoting an understanding of the intricate socio-ecological dynamics and fostering behaviour change towards sustainability.

The intersection matrix is a valuable tool for researchers, in addition to its practical implications for policymakers and landscape managers. It offers a framework that future studies can build upon, demonstrating its effectiveness in understanding socio-ecological dynamics. Researchers can adapt the matrix approach to investigate other landscapes, tailoring it to their specific contexts and research questions. By utilizing the matrix, researchers can gain insights into driving force interactions, identify key factors, and evaluate their significance across different landscapes. The matrix serves as a reference for comparative studies, enabling researchers to assess similarities and differences between landscapes, and identify common patterns and trends. It also contributes to scientific knowledge by providing a systematic and comprehensive analysis of driving forces and their intersections, encouraging methodological advancements and interdisciplinary collaboration.

4 Conclusions

This paper presents several important results that contribute to the understanding of the Jordan River Basin and the broader field of landscape management. Firstly, the developed methodological framework demonstrates its efficacy in capturing the overlapping processes between natural and cultural driving forces, enabling a comprehensive analysis of their relationship and impact on the landscape. The case study conducted in the Jordan River Basin serves as a valuable example of the framework's practical application and successful achievement of research objectives. For example, through this framework, researchers can systematically study how changes in the river's morphology, such as alterations in its course or water flow, affect the communities living along its banks. They can collect data on historical shifts in the river's morphology, conduct interviews and surveys with affected communities, and analyse cultural practices and settlements in the region.

These findings pave the way for future research and experimental work in the field. Researchers can build upon this framework by applying it to other landscapes or regions, adapting it to their specific contexts and research questions. By incorporating additional factors, exploring new data sources, or refining the methodology, further advancements can be made in understanding the socio-ecological dynamics of diverse landscapes.

The results presented in this paper have important implications for academic and professional practice. Policymakers, landscape managers, and planners can utilize the insights gained from this study to develop more effective policies and management strategies for sustainable landscape management.

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